



ORIGINAL RESEARCH ARTICLE

TOWARDS IRRIGATION MODERNISATION IN THE OGUN-OSHUN RIVER
BASIN, NIGERIA: OPPORTUNITIES, CHALLENGES, AND IMPROVEMENT
OPTIONS

O.B. Adebeye¹, D.J. Oyedele², V.A. Tanimonure³, A.O. Opayinka⁴, O.E Aduwo⁵,
A.T. Olusegun⁶, A.A. Yusuf⁶, L.A. Oyewole⁶, O.O. Odunaiya⁶, A.D. Chukalla⁷, E.B.
Aduagna⁸, T.T. Solomon⁸, C.N. Selamawit⁸, A.K. Zera⁸, H. Mahlet⁸, A.G. El-Naggar⁷,
C. de Fraiture⁷

¹Department of Agricultural and Environmental Engineering,

²Department of Soil Science and Land Resources Management,

³Department of Agricultural Economics,

⁴Department of Agricultural Extension and Rural Development,
Obafemi Awolowo University, Ile-Ife, Nigeria

⁵Department of Sociology, University of Ilesa, Nigeria

⁶Ogun-Oshun River Basin Development Authority, Abeokuta, Nigeria

⁷IHE Delft Institute for Water Education, Delft, the Netherlands

⁸Jimma University College of Agriculture and Veterinary Medicine

*Corresponding author's Email: adeboyeob@oauife.edu.ng

ARTICLE INFORMATION

Received: 3rd November 2025
Revised: 10th December 2025
Accepted: 4th February 2026

Keywords:

Irrigation
Ogun-Oshun River Basin
Land and water resources
policy
Modernisation
Nigeria
Agriculture

ABSTRACT

Irrigated agriculture is very crucial in achieving the Sustainable Development Goal (SDG) and ensuring food security in Nigeria. The study examines the opportunities and the challenges of the selected thirteen Irrigation Farm Projects in the Ogun-Oshun River Basin Authority (OORBA). Data were obtained by interviews from the stakeholders in the management of the irrigation schemes. The study reveals that land areas range from 150 ha for the Lower Ogun Irrigation Project in Mokoloki to 3,500 ha for the Middle Ogun Irrigation Project in Iseyin. However, the level of utilisation of the land resources varies from 6.2% to 100%. Interestingly, it was observed that a good correlation between the irrigable land area and the area actually irrigated ($r^2 = 0.7982$), and the irrigable areas and the actual irrigated areas under large Irrigation Farm Projects ($r^2 = 0.70$) exist, unlike the small Irrigation Farm Projects ($r^2 = 0.09$). Therefore, it indicates that the smallholder farmers in the large Irrigation Farm Projects utilised the land resources better. However, where underutilisation was pronounced, it is due to ageing irrigation and energy infrastructure, poor access roads and networks, and inadequate modern farm machinery. Surface water resources are abundant in the selected Irrigation Farm Projects, which, if well explored, could transform the irrigated agriculture in the basin and reposition OORBD as the food basket for the Southwest, Nigeria and the neighbouring African countries. The poor performance of the public Irrigation Farm Projects in the OORBD is due to low financial investment in the projects, poor economic conditions, lack of weather early warning systems and networks to mitigate the effects of climate change. Opportunities for transforming irrigated agriculture in the basin are the application of sensors in irrigation water management and drones for smart agriculture, renewable energy, micro-irrigation systems, access roads and market, regular training of farm managers and the early warning systems networks.

1.0 Introduction

Agriculture in the 21st century is facing several challenges. These include the production of food to feed the huge and increasing human population (Miladinov, 2023), with a low labour force in rural areas (Rufai *et al.*, 2021), and reducing rural poverty (Bjornlund *et al.*, 2022; UN, 2023). Others are creating more resilient agroecosystems and adapting to climate change (Minoli *et al.*, 2022); implementing efficient and sustainable production techniques and practices (Gaviglio *et al.*, 2021) among the smallholder farmers and the sustainable management of the natural resource base (Yadav *et al.*, 2024). It is noteworthy that feeding a growing population amid climate variability demands substantial productivity gains, poverty reduction, and resilience in agri-food systems (Villacis *et al.*, 2022). To achieve the SDG target goal 2 (Zero Hunger) hinges on closing yield gaps and stabilising production (Ongoma *et al.*, 2025), while SDG 6.4 calls for improved water-use efficiency and reduced scarcity in agriculture, the largest consumptive water user (Hellegers & van Halsema, 2021). In Sub-Saharan Africa (SSA), food insecurity is very high, with an average crop yield of 1–250 kg/ha of cereal compared to the global average of 4–100 kg/ha (OECD/FAO, 2024). There is a rise in undernourishment from 17.6% of the population in 2014 to 19.1% in 2019 (FAO, 2023).

The SDG 2 emphasises zero hunger and food security in vulnerable regions. Additionally, SSA is the only region on the planet where chronic food insecurity remains endemic (Giller, 2020). A recent estimate shows that about 282 million people in Africa (20 % of the population) were undernourished in 2022, an increase of 57 million people since the COVID-19 pandemic began (Kamgnia & N'Dri, 2025)). In addition, nearly 868 million people were moderately or severely food-insecure, and 342 million were severely food-insecure (FAO, 2023). To satisfy the expected food and feed demands amid climate change, there is a need for about a 70% increase in global food production by the year 2050. Several options have been given to revolutionise agriculture and ensure food security. One of the prominent options is exploring the potential of irrigated agriculture, especially in developing countries (Takeshima & Adesugba, 2014; Xie *et al.*, 2017). Expanding and modernising the existing irrigation systems and infrastructures offers a pathway to stabilise output, intensify cropping, and reduce vulnerability. Since the late 1970s, Nigeria's River Basin Development Authorities (RBDAs) have been commissioned to develop and manage surface and groundwater for multipurpose use, including irrigation and urban supply. The Ogun–Oshun River Basin Development Authority, despite multiple Irrigation Farm Projects established to harness land and water resources, the actual irrigated area and overall utilisation appear well below the command area in many schemes.

Rainfed agriculture is the predominant farming system in Nigeria and most of SSA (OECD/FAO, 2016; Xie *et al.*, 2017). About 6% of the agricultural land in SSA is irrigated (Hanjra & Williams, 2020). The rainfed agricultural system in Nigeria is very vulnerable to extreme weather events, posing a high risk to the production systems (Olayide *et al.*, 2016; Tajudeen *et al.*, 2022). Although it depends on geographical zones, rainfall shock affects agricultural productivity to varying degrees (Amare *et al.*, 2018). Low rainfall has been found to reduce the yields of maize, yams and cassava in Nigeria (Emaziye, 2015). Another extreme meteorological event is the heat stress caused by extreme air temperature. Air temperature has increased due to global warming and is projected to affect the yields of crops in Nigeria (Adeboye *et al.*, 2021; Tajudeen *et al.*, 2022). Heat stress has been identified as a major threat to the yield of maize (Li *et al.*, 2022). Also, it has been reported that it has influenced crops sensitive to air temperature, and temperature-induced stress has reduced crop productivity (Akpodigaga-a & Odjugo, 2010; Osuji *et al.*, 2023). However, Climate change, initiated by extreme local weather conditions, impacts pearl millet (Emediegwu *et al.*, 2022). Therefore, irrigated agriculture is a pragmatic approach to reducing risks associated with crop production in vulnerable regions. Therefore, there is a need to explore water resources for irrigated agriculture to adapt to changes in weather conditions.

The Ogun-Oshun River Basin covers a land area of about 23,700 km² (Ojekunle *et al.*, 2011). It is one of the twelve (12) River Basin Authorities established to achieve this purpose. There are 26 farm projects in the river basin, which were established to manage huge land and water resources for agriculture and dispense inputs to farmers to grow crops for food security (Adeboye & Alatise, 2008). However, there are constraints and challenges in exploring the water resources, especially for dry-season farming. These include energy cost, conveyance losses, governance and data gaps. Ogun-Oshun River Basin Development Authority, Abeokuta, Southwest, Nigeria. The river basin covers Ogun, Oyo, Osun and Lagos States, which have highly concentrated and enlightened populations, most of which live in towns and cities. There has not been consolidated, basin-wide evidence on (i) actual irrigated area/utilisation vs. command area; (ii) performance of the infrastructure (headworks and conveyance, field applications), and service provision and management institutions, etc; (iii) prioritisation logic for rehabilitation/expansion. This study, therefore, aims to identify the specific challenges and untapped opportunities within the OORBDA's irrigation schemes to inform a modernisation strategy.

2. Materials and Method

2.1 Study Area

The study was conducted in the Ogun-Oshun Basin, Nigeria. The basin is located between longitude $3^{\circ}23' - 5^{\circ}10'$ E and latitude $6^{\circ}30' - 8^{\circ}20'$ N (Figure 1). Ogun-Oshun River Basin has an estimated land area of 66,264 km². The area of the basin covers the whole of present-day Osun, Oyo, Ogun and Lagos states of Nigeria. It is drained by the Ogun and Osun Rivers and several tributaries and smaller rivers, including Sasa, Ona, Ibu, Ofiki, Yewa, Igbo-ljaye and Sepeteri (Yaqoob *et al.*, 2021). The headquarters of the river basin authority is located on a 236 ha estate along Alabata road, off the Ibadan-Abeokuta highway, Abeokuta in Ogun state. It has three area offices located at Oshogbo (Osun state), Ibadan (Oyo state) and Ikeja (Lagos state), as well as a liaison office at Gwarinpa in Abuja, the Federal Capital Territory.

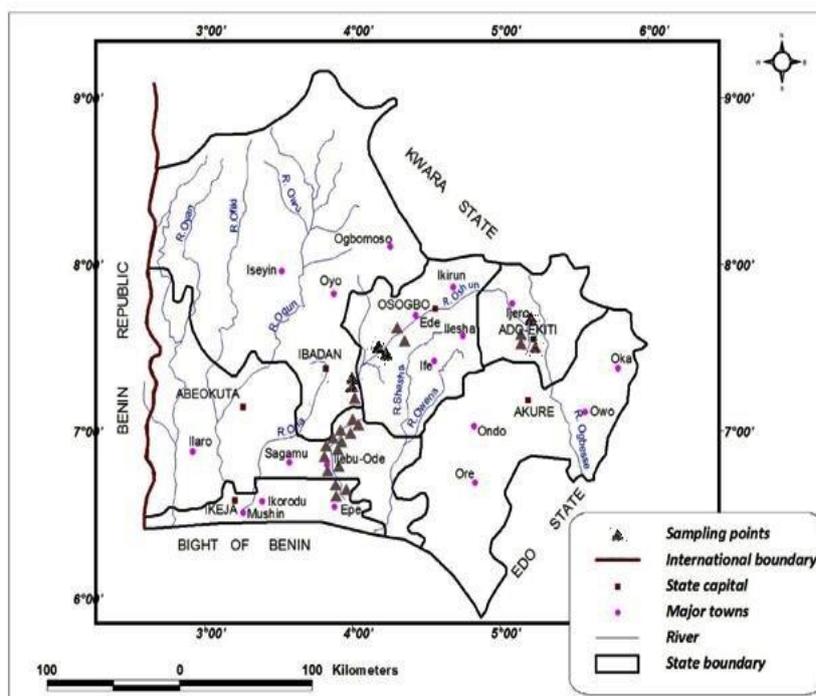


Figure 1: The Ogun-Oshun River Basin Development Authority (Ewemoje & Ewemooje, 2011).

2.2. Data Collection and Analysis

Thirteen Irrigation Farm Projects under the OORBDA were selected for assessment. Data were collected through oral interviews, field visits and physical inspections by the research team, focusing on land availability, extent of irrigation, infrastructure condition, and functionality. The farm managers, workers, tractor operators and experienced old farmers under the Irrigation Farm Projects were interviewed. The questions asked include land area and actual irrigated area; sources of water for irrigation (surface, groundwater, reservoirs, diversion structures); Irrigation methods in use (surface, center pivot, drip, gravity, flooding); condition of headworks (pump stations, dams, diversion weirs); Conveyance and distribution methods (lined/earthen canals, pipes, cascade systems); major crops cultivated; challenges in operation, maintenance, energy use, and governance. We hereby hypothesise that there is a high correlation between the size of irrigable land and the actual irrigated land area in the Irrigation Farm Projects of Ogun-Oshun River Basin, Nigeria

2.3 Geo-referenced Scheme Audit

Each Irrigation Farm Project was geo-referenced using GPS, and information on land area, irrigated area, water infrastructure, and cropping was compiled into a spatial database. This allowed for mapping schemes' distribution, utilisation levels, and resource endowments. The level of utilisation in each Irrigation Farm Project was determined by dividing the irrigable land area by the actual irrigated area. The correlation between the irrigable land and the actual irrigated land area was also determined using the coefficient of determination (r^2). The sizes of the irrigable land area were categorised into two (i) Large, that is, area higher than or equal to 1000 ha, and (ii) small, that is, area lower than or equal to 999 ha. The correlation between the large and small irrigable land areas and the actual irrigated area was determined.

2.4 Irrigation Performance Assessment

The level of land utilisation was calculated as the ratio of irrigated area to command area for each irrigation scheme. Where available, dam and reservoir capacities were cross-checked with secondary sources. Other data and information were obtained from the stakeholders in each Irrigation Farm Project using a structured interview.

2.5 Multi-criteria Decision Analysis for prioritize Schemes for performance/Utilisation Improvement

To prioritise schemes for rehabilitation or expansion, a Multi-Criteria Decision Analysis framework was applied. The criteria included technical performance (utilisation %, infrastructure condition); water availability (storage/reservoir capacity, dependable flow); energy requirements and options (diesel vs. solar pumping); socio-economic relevance (number of farmers served, crop diversity, market access).

3. Results and Discussion

3.1 Command Area and Actual irrigated Utilisation

The selected Irrigation Farm projects have abundant and fertile land resources, which have not been fully explored for irrigated agriculture. The Middle Ogun Farm Project has the largest land capacity, but with only 16% utilisation for irrigated agriculture (Table 1). The percentage utilisation of available land area for irrigated agriculture ranges from 6.2% in the Iwo Irrigation Farm Project to 100% in the Asa Irrigation Project. These are considered very low compared with the irrigable land area in the basin. The low utilisation of the land for irrigated agriculture, especially in the Ikere Gorge Irrigation Farm Project, the Middle-Ogun farm Project, and other Irrigation Farm Projects, could be attributed to high annual rainfall, technical and financial challenges that are associated with irrigated agriculture in the area. This necessitated the cultivation of crops during the rainy season only and the outright abandonment of the agricultural land during the dry season. Although there have been incidences of dry spells in recent times in the area, yet, the smallholder farmers in the area depend so much on rainfall.

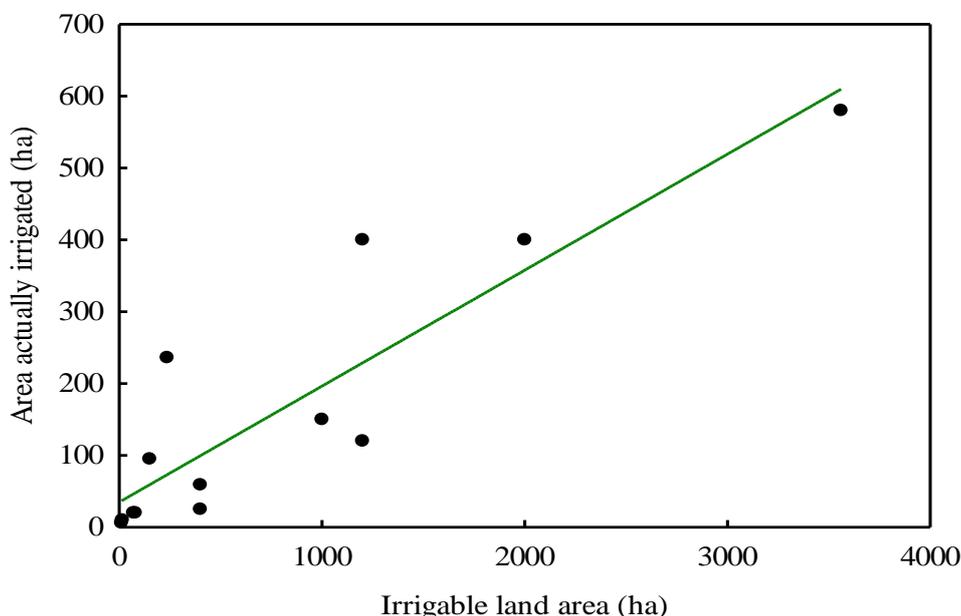


Figure 2: Correlation between irrigable land area and the land area that is actually irrigated

There is a good correlation between the irrigable land area (Figure 2) and the area actually irrigated ($r^2 = 0.7982$, $p < 0.0001$). This indicates that the smallholder farmers in the area have been practising dry-season farming and could expand their cultivated areas if conditions are more favourable. Similarly, there is a high correlation between the irrigable areas and the actual irrigated areas under large Irrigation Farm Projects ($r^2 = 0.70$, $y = 0.1516x + 58.25$, $p < 0.1625$), unlike the small Irrigation Farm Projects ($r^2 = 0.09$, $y = 0.1493x + 33.45$, $p < 0.0167$). Higher utilisation of land resources in large irrigation projects could be attributed to the provision of irrigation facilities, especially at the onset of the schemes in the 70s and 80s. However, the smaller irrigation schemes are mostly used by a few farmers who rely on incentives and inputs from the local authority.

Table 1: Selected Irrigation Farm Projects, land capacity and the irrigation system in the Ogun-Oshun River Basin, Nigeria

| S/N | Irrigation Scheme/ Farm Project | Land area capacity (ha) | Area irrigated (ha) | Utilisation (%) | Headworks Infrastructure | Water Conveyance of the main system | Irrigation Methods | Dam/weir capacity (million m ³) | Water availability (m ³ /ha) | Major Crops |
|-----|------------------------------------|----------------------------|------------------------|--------------------|-------------------------------|-------------------------------------|---|--|--|---|
| 1 | Middle Ogun Irrigation, Iseyin | 3,560 | 580 | 16 | Concrete dam, Pump station, | PVC pipe and earthen canals | Centre pivot and drip | 200 | 56,180 | Maize, tomato, cassava, and vegetables |
| 2 | Igbojaiye Farm Project | 2,000 | 400 | 20 | Earth dam | Earthen canals | Surface, gravity irrigation, and flooding | 5.6 | 2,800 | Maize, cassava, soybeans, yams |
| 3 | Sepeteri Irrigation Farm | 1,200 | 120 | 10 | Earth dam | Gasoline water pump | Centre pivot, surface and drip | 2.1 | 1,750 | Maize, cassava, and vegetables |
| 4 | Ofiki Irrigation Project | 1,200 | 400 | 33 | Earth dam | Earthen canals | Centre pivot, surface and drip | 0.64 | 533 | Maize, cassava, amaranthus |
| 5 | Itoikin Irrigation Project | 1,000 | 150 | 15 | Water reservoir, Pump station | Pump gravity intake + irrigation | Flooding and surface irrigation | 3.4 | 3,400 | Maize, Cassava, amaranthus, ewedu, watermelon, |
| 6 | Oke-Odan Irrigation Project | 400 | 59 | 15 | Earth dam | Pump gravity intake + | Centre pivot | 5.2 | 13,000 | Maize, watermelon, golden melon, okra, maize, cucumber, pepper, cassava, and vegetables |
| 7 | Iwo Irrigation Farm Project | 400 | 25 | 6.2 | Concrete Dam, Pump station | Earthen canals | Centre pivot, flooding and drip | 1.5 | 3,750 | Maize, amaranthus, okra, watermelon, cassava and sorghum |

| | | | | | | | | | | |
|----|-------------------------------|------|-----|-----|----------------|----------------|--|------|------------|---|
| 8 | Asa Irrigation Project | 236 | 236 | 100 | Earth dam, | Earthen canals | Surface irrigation | 0.81 | 3,432 | Maize, cassava |
| 9 | Lower Ogun Irrigation Project | 150 | 95 | 63 | Diversion weir | Earthen canals | Centre pivot, drip and flooding Centre pivot, and surface irrigation (furrow, border) Centre Pivot and surface irrigation (Furrow, basin and border) | 2.5 | 16,667 | Maize, garden egg, melon, okra, and watermelon |
| 10 | Igan Alade Irrigation Project | 80 | 20 | 25 | Earth dam | Earthen canals | Centre pivot, and surface irrigation (furrow, border) Centre Pivot and surface irrigation (Furrow, basin and border) | 1.5 | 18,750 | Watermelon, tomato, cucumber, maize, and pepper. |
| 11 | Ikere Gorge irrigation | 70 | 20 | 29 | Concrete Dam | PVC Pipe | Centre pivot, and surface irrigation (Furrow, basin and border) | 565 | 8,071,429 | Maize, pepper, tomatoes, cassava, and yams |
| 12 | Pade Irrigation Farm Project | 15 | 10 | 67 | Pump station | PVC pipe | Centre pivot, and surface irrigation Surface (furrow), flooding irrigation | 0.7 | 46,667 | Maize, cucumber, watermelon, rice, okra, beans and leafy vegetables |
| 13 | Oyan Irrigation Project | 11.2 | 6 | 54 | Butress dam | Earthen canals | Surface (furrow), flooding irrigation | 270 | 24,107,143 | Maize, vegetables and cassava |

3.2 Water resources availability for Irrigation

Based on physical assessment, most of the Irrigation Farm Projects are endowed with abundant surface and groundwater resources (Plates 1-3). The natural water courses designed for diversion to the agricultural land are available and being fed by water from the upstream continuously. For instance, the Ikere Gorge dam has a total capacity of 565 million m³ of water and a surface area of 47 km² (Babatunde *et al.*, 2024). Dam capacities in the selected Irrigation Farm Projects range from 0.64 in Ofiki to 565 million m³ of water in Ikere (Table 1). These translate into 533 m³/ha in Ofiki to 24,107, 143 m³/ha for Ikere. The available water is adequate and can support arable crops throughout the dry season. The medium and huge dams can support water storage for dry-season farming and the generation of electricity to the national grid for industrial use (Adeyemo, 2016; Odunfa *et al.*, 2019).



Plate 1: Water resources for agriculture and the generation of energy at the Ikere George multipurpose dam in Iseyin.



Plate 2: Surface water resources in the Middle Ogun Irrigation Project in Iseyin, Oyo State, Nigeria

The Oyan dam in Ogun State contains an average of 270 million m³ of water and is adequate to support irrigated agriculture and the ecosystem services in the area (Ayeni & Ojifo, 2018). The Sepeteri and Ofiki dams in Oyo State, built to support irrigated agriculture, have capacities of 3.4 million m³ and 1.67 million m³ of water, respectively (Adeboye *et al.*, 2024). The reservoir in the Oke-Odan Irrigation Farm Project, Ogun State, has a capacity of 5.62 million m³ of water and could support diverse agricultural activities such as pastoral farming, fishery, and irrigated agriculture. The water reservoir capacity in the middle Ogun Irrigation Farm Project in Iseyin is 0.56 million m³ and is adequate for dry-season farming over a land area of 3,560 ha (Table 1). It is very evident that the river basin is endowed with abundant land and water resources to ensure food security in the basin and the country.



Plate 3: Abundant surface water resources in the Sepeteri Irrigation Farm Project in Sepeteri, Oyo State, Nigeria. The smallholder farmers use a gasoline water pump to deliver water to the field and grow their crops.

3.3 Irrigation Scheme Challenges: Infrastructure from Headwork to Field Application, Operation and Maintenance, and Intuition

Despite the abundant land and water resources in the basin, it is evident that irrigated agriculture is at the lowest level of development in the selected farm projects. The poor performance of the Irrigation could be attributed to the following reasons:

3.3.1 Ageing irrigation facilities

Irrigation has been identified as a way to increase agricultural productivity, and investments in new irrigation facilities are planned in several areas across SSA, including the Ogun-Oshun River basin, Southwest Nigeria (OECD, 2020). Most of the public irrigation schemes in the basin have very old facilities. These include water pumps installed in the 1960s and early 1970s by the government of the Old Western region of Nigeria. For instance, the gasoline-engine-driven water pumps in the Itoikin Farm Project were installed in 1970 (Plate 4), while those of Oke-Odan and the centre pivot irrigation system were installed in the year 2010. The water pumps in the Middle-Ogun Farm Project, Iseyin were installed in 1980s (Plate 5). The water pumps in Sepeteri and Ofiki were installed in 1995, while their centre pivot irrigation system were installed in the year 2010. In the Lower Ogun Irrigation Farm Project, Mokoloki, the water pumps for powering the centre pivot system were installed in the year 1972, while the centre pivot system was installed in the year 2011. Most of these facilities are old and, due to long periods of poor maintenance, they are not efficient in conveying water to the field for dry-season farming years (Bjornlund *et al.*, 2020a).



Plate 4: Ageing water pump for conveying water from a reservoir to the field in the Itoikin Irrigation Farm Project, Lagos State, in Nigeria

The challenge of ageing facilities is not peculiar to the public irrigation schemes in Nigeria; it is seen in most of the government-owned irrigation schemes in Africa (Bjornlund *et al.*, 2020a; Mwamakamba *et al.*, 2017; Xie *et al.*, 2017). The age and poor state of these facilities must have reduced their pumping efficiency and performance.



Plate 5: Ageing irrigation facilities in the Middle-Ogun Irrigation Farm project in Iseyin, Oyo State, Nigeria

3.3.2 Earthen canals

Most of the channels for conveying water to the field in the selected Farm Irrigation Projects are unlined earthen channels. The unlined earthen channels are very porous and erode over time due to environmental conditions (Plates 6 and 7). This reduces their conveyance efficiencies and lowers the performance of the irrigation system.



Plate 6: An unlined earthen channel for conveying water to the field in the Asa Farm project, Oyo State, Nigeria

3.3.3 Huge Cost of Operation

In Nigeria, the cost of operating the water pumps at the time of installation was very low compared to the cost in the current economic situation. The operating costs of the water pumps were highly subsidised or done almost for free of charge for the farmers shortly after installation in the 70s and 80s. This is because agriculture was treated as a social development strategy (Ikueomonisan, 2024). However, the current economic realities have shown that the government cannot bear all the responsibilities of providing services to all the smallholder farmers in the Irrigation Farm Projects in the river basins. Therefore, the farmers have been asked to contribute towards the provision of these services, such as the purchase of diesel, seasonal rent on land, and service charges on tillage operations, etc. Often, the smallholder farmers cannot pay the stipulated fees due to their poor economic conditions or feel that it is the responsibility of the government to provide these services freely. These affect irrigated agriculture and cause abandonment of land and water resources in the Irrigation Farm Project, especially during the dry season (Rai *et al.*, 2017). The huge cost of operating the

irrigation system is a factor for the low level of land utilisation of available land for irrigated agriculture in the selected farm projects (Table 1).



Plate 7: An unlined earthen channel for conveying water to the field in the Middle Ogun Farm Project, Iseyin, Oyo State, Nigeria

3.3.4 Irrigation system

The choice of irrigation systems is another factor for the poor performance of the public or private irrigation systems in the Ogun-Oshun River Basin, Nigeria. The irrigation systems in most of the basins in the developing countries were donated to the African countries by Western superpowers without considering their technical know-how to manage them (Cambaza *et al.*, 2020). After independence, governments in SSA continued to develop irrigation schemes with the backing of the donors. These irrigation schemes were not driven by the economic interests of the farmers and were not used to enhance production systems for local development (Bjornlund *et al.*, 2020b). Rather, the development and management of irrigation schemes were driven by the political and social objectives of governments, and often at odds with farmers' interests. In contrast, the complex agricultural water management (AWM) practices endogenous to SSA were adapted in scale and management to their socio-economic and biophysical environments, as in many places such as the Ogun-Oshun River Basin, (Bjornlund & Bjornlund, 2019). We use the term 'government schemes' to describe irrigation schemes where the government has substantial control over their management. New irrigation systems donated to communities of smallholder farmers on many occasions are like political bait to gain popularity for election purposes, not to fundamentally meet the demands of the people for economic and environmental sustainability (Bjornlund *et al.*, 2020a). These, coupled with local challenges, affect the functionality and exploration of the available irrigation facilities. The centre pivot irrigation system in most of the selected Farm projects are complex and requires huge energy and technical know-how to operate and maintain (Plate 8). In situations where staff trained to operate the system are not available, or the components of the system are faulty, and the components are not available in the local markets, the system could be rendered redundant for many years.

3.3.5 Biophysical Environment in the Basin

Many farmers complained that the poor performance of the public and large-scale irrigation scheme is due to issues inherent to their community's biophysical environment and its people. For instance, degraded soils, droughts and floods, labour shortages, ignorant farmers, backwards farming methods and small-scale farming systems (Tadele, 2017). Studies over the years also focus on the high cost of development, poor management, lack of rural finance, expensive input such as fertiliser, and lack of modern infrastructure (Mupaso *et al.*, 2023).

It is evident, based on the field survey, that irrigation scheme developers, donors and the river basin authority have failed to understand that irrigation schemes are complex systems. Most smallholder farmers cultivate less than 5 ha per season, except in Oke-Odan, where a few commercial farmers cultivate about 10 ha. The public irrigation schemes or projects can only be successful if operations are within the constraints of the available water resource and are part of a functional rural economy that is integrated with markets, transportation, and information systems. The schemes must be with the right economic models for profitable ventures and ensure improvement in the livelihood of the smallholder farmers. Otherwise, the public irrigation

schemes and Farm Projects will continue to perform poorly, and the available land and water resources will remain underutilised.



Plate 8: A centre pivot (drop tube) irrigation system at the Ikere irrigation project in Ikere, Oyo state, Nigeria, installed to irrigate 20 ha of farmland. (Source: Photo taken during baseline study of the PISTA on 4th March 2024).

3.6 Multi-criteria evaluation for irrigation scheme

The Middle Ogun Farm Project has the largest fertile land area in the Ogun-Oshun River basin. However, about 16% of the available land area is utilised for irrigated agriculture (Table 1). The farm project has the largest land area dedicated to irrigated agriculture. Study reveals that the pumps in the headworks are faulty and have been abandoned for more than a decade (Adeboye et al., 2025). The smallholder farmers in the area use a gasoline engine (1 hp) to irrigate their maize and vegetables. About 33% and 20% of the land areas in Igbojaiye and Ofiki Farm Projects, respectively, are used for irrigated agriculture. The low land utilisation for dry season farming in these areas could be attributed to poor maintenance of the earthen canals or the water reservoirs in the farm projects, and the lack of electricity in the farm projects. The sprinkler irrigation systems provided by the river basin in the Ofiki Farm Project are faulty and have been abandoned for a long time, hence another reason for the low utilisation of farmland for irrigated agriculture. At the Lower Ogun Irrigation Farm Project in Mokoloki, 63% of the available land is used for dry-season farming. The centre pivot sprinkler system on the project is faulty, and coupled with the high cost of operation and maintenance, utilising additional land for dry-season farming in the project is difficult. The Asa farm project, with a land area of 236 ha, is the only project where 100% of the land is utilised for irrigated agriculture. In Oke-Odan and Sepeteri Farm Projects, 15 and 10% of the farmlands are used for irrigated agriculture. The low utilisation of the farmland is due to the poor, inadequate farming facilities, for instance, and the insecurity in the areas.

High energy cost is one of the major challenges of full utilisation of the available land area under the Farm Irrigation Projects in the basin. The smallholder farmers who powered the centre pivot sprinkler system to irrigate their farmlands find it difficult to break even at the end of a season due to the high cost of production.

3.7 Opportunities for Irrigation Scheme Modernisation

The huge irrigable farmlands in the selected Farm projects in the basin provide ample opportunities for prospective investors in irrigated agriculture. Most of the selected Farm Projects in the basin, and some other agro-ecological zones in Nigeria, lack modern agricultural and irrigation facilities. The earthen canals constructed about 50 years ago are currently weak, dilapidated and in many cases have collapsed. The water pumps are completely old and need replacement with modern and more efficient facilities. Opportunities for irrigation scheme modernisation include the use of sensors in agricultural water management (Obaideen et al., 2022) and drones for smart agriculture (Guebsi et al., 2024; Rajak et al., 2023; Soussi et al., 2024), renewable energy to reduce operation costs (Majeed et al., 2023), and the use of high precision techniques like micro-irrigation (Kumar et al., 2021). Other opportunities for modernising and transforming water management for agriculture at the basin level include regular training of farm managers who are in direct contact with the smallholder farmers; stakeholder participation in planning and implementation of projects from the

government and the Non-governmental Organisations. Others are the installation and management of automatic weather stations and early warning systems networks (Kumar *et al.*, 2021). Smart agricultural water management depends largely on quick access to weather conditions and forecasts via modern instrumentation (Botero-Valencia *et al.*, 2022). There is neither a digital nor an analogue weather station in the selected Irrigation Farm Projects visited in the basin. The farmers lack access to this data and are unaware of the weather conditions in their locality. This will ill-prepare the farmers for sudden changes in the weather conditions, which could be very devastating to their agricultural productivity. Therefore, it is essential to plan the installation and maintenance of a mini weather station in each Irrigation Farm Project. The farm managers should be trained on the mode of operation of the weather stations and the interpretation of the weather data for the local and smallholder farmers.

Adoption of stress-tolerant indigenous and high-yielding crop varieties (Bekuma *et al.*, 2023) is very crucial to ensure reliable seed banks among the rural populace. Motorable access roads are very crucial for the smooth running of agricultural activities. Access roads to most of the selected Irrigation Farm Projects are in deplorable conditions, for instance, the Iseyin-Ikere road that leads to Ikere Gorge Farm Project. Rehabilitation and expansion of the existing road networks in the area will facilitate the transportation of irrigation/agricultural facilities and provide a reliable route to markets farm produce. The existing irrigation facilities in the basin need to be modernised to ensure higher water delivery, application and utilisation by plants. An infrastructure upgrade should include the provision of climate-smart solar energy facilities for pumping water to the field, especially under the public irrigation schemes where a farmer cultivates more than 5 ha of land. A portable solar-powered water pump should be provided for the smallholder farmer whose agricultural land is up to 5 ha. This will reduce the high cost of operating gasoline water pumps under the present economic conditions.

Creation of a Water Users' Association in each Irrigation Farm Project will bring all the farmers and water users together. It will create an avenue for collective decisions on the mode of exploring water resources for dry-season farming. It will create an avenue for dialogue with the river basin authority on the roles of smallholder farmers in protecting the water bodies from pollution and in managing the water resources for food security (Suraj *et al.*, 2025).

Most of the current policies for operating and managing water resources at the basin scale are either obsolete or static. They fail to blend with the modern economic trends and realities. The public irrigation schemes under the River Basin Development Authority are not managed for profit; rather, they are managed as a development agency which receives financial allocation annually and yet food security is still unattainable. In order to make the Ogun-Oshun River basin functional and serve the community and the nation better, there is an urgent need for policy reformation. This should reexamine the roles of the stakeholders, such as the government at various levels, funding models that consider fluctuations in the market prices of commodities and the vulnerability of the smallholder farmers to the national economic decisions (Mwamakamba *et al.*, 2017). The government needs to state clearly the roles to play in irrigated agriculture and water resources management, and the level of subsidies to be provided for the farmers to ensure food security. Markets for the agricultural produce must be provided within the Irrigation Farm Projects in the Ogun-Oshun River basin to prevent extortion by the middlemen.

4. Conclusion

The paper examines the opportunities, challenges and means of modernising irrigated agriculture in the selected Irrigation Farm Projects in the Ogun-Oshun River basin. The study reveals that irrigable farm land ranges from 150 ha for the Lower Ogun Farm Project, Mokoloki, to 3,500 ha for the Middle Ogun Irrigation Farm Project, Iseyin. The level of utilisation for irrigated agriculture ranges from 6.2% for the Iwo Farm Project to 100% for the Asa Farm Project. Utilisation of land for irrigated agriculture is higher where irrigable land is higher than 1000 ha, unlike in smaller irrigation schemes. There are abundant water and land resources in the selected Farm Projects in the basin, which, if well explored, could transform the irrigated agriculture in the basin and reposition Nigeria as the food basket for the West African sub-region. The constraints to the poor performance of the selected Irrigation Farm Projects include old and ageing agricultural and irrigation facilities, earthen canals and very poor access roads. Others are the lack of policy guidelines on water use, water rights and sustainable policy on the development and management of water resources for irrigated agriculture at the farm level and basin scales. The high cost of operating the centre pivot sprinkler irrigation systems provided by the River Basin Development Authority for the Selected Farm Projects makes irrigated agriculture unprofitable for the smallholder farmers. There are several opportunities for modernising irrigated agriculture in the basin, and these include sensors and drones for climate-smart agriculture, cost-effective renewable

energy and micro-irrigation. Similar studies should be carried out in other river basins in Nigeria, and future research should integrate remote sensing diagnostics, digital monitoring tools, and participatory governance models to provide continuous performance assessments of the irrigation schemes.

Funding

This work was supported by the IHE Delft Water and Development Partnership Programme for the consortium "Partnership for Irrigation System Transformation in Africa (PISTA), under Grant Number 111128.

References

- Adeboye, OB. and Alatise, MO. 2008. Surface Water Potential of the River-Osun at Apoje Sub-basin Nigeria. *Soil Water Research*, 3(2): 74-79
- Adeboye, OB., Matthew, OJ., Adeboye, AP., Schultz, B. and Adekalu, KO. 2021. Analysis of Sensitivity of Soybean Yield to the Increasing Temperature under Humid Tropical Climate of Nigeria. *International Journal of Agriculture, Environment and Biotechnology*, 14(4): 601-613
- Adeboye, OB., Oyedele, DJ., Tanimonure, VA., Opayinka, A., Aduwo, OE., Olusegun, A., Yusuf, AA., Oyewole, L., Olayemi, O., Bekele, A., Tadesse, ST., Nagassa, S., Kedir, Z., Hailu, M., Aba, A., Sahile, A., Chukalla, AD., de Fraiture, C. and Elnaggar, A. 2024. *Baseline report on irrigated agriculture in Ogun-Oshun river basin, Nigeria*. PISTA. 31 pp.
- Adeyemo, O. 2016. Operational performance of Ikere-gorge dam in Iseyin local government area of Oyo State, South-Western Nigeria. *International Journal of Advanced Academic Research*, 2(8): 19-28
- Akpodiogaga-a, P. and Odjugo, O. 2010. General Overview of Climate Change Impacts in Nigeria. *Journal of Human Ecology*, 29(1): 47-55
- Amare, M., Jensen, ND., Shiferaw, B. and Cissé, JD. 2018. Rainfall shocks and agricultural productivity: Implication for rural household consumption. *Agricultural Systems*, 166: 79-89
- Ayeni, A. and Ojifo, L. 2018. The socio-economic dynamics of Dam on Rural Communities: A case study of Oyan Dam, Nigeria. *Proceedings of the International Association of Hydrological Sciences*,
- Babatunde, MA., Ojediran, JO. and Okekunle, PO. 2024. Assessment of Water Resources Potential of Ogun River for Irrigation Purposes at Middle Ogun Irrigation Project. *Asian Journal of Advances in Agricultural Research*, 24(6): 70-81
- Bekuma, T., Mamo, G. and Regassa, A. 2023. Indigenous and improved adaptation technologies in response to climate change adaptation and barriers among smallholder farmers in the East Wollega Zone of Oromia, Ethiopia. *Research in Globalization*, 6: 100-110
- Bjornlund, V. and Bjornlund, H. 2019. Understanding agricultural water management in a historical context using a socioeconomic and biophysical framework. *Agricultural Water Management*, 213: 454-467
- Bjornlund, V., Bjornlund, H. and van Rooyen, A. 2022. Why food insecurity persists in sub-Saharan Africa: A review of existing evidence. *Food Security*, 14(4): 845-864
- Bjornlund, V., Bjornlund, H. and van Rooyen, AF. 2020a. Exploring the factors causing the poor performance of most irrigation schemes in post-independence sub-Saharan Africa. *International Journal of Water Resources Development*, 36(sup1): S54-S101
- Bjornlund, V., Bjornlund, H. and Van Rooyen, AF. 2020b. Why agricultural production in sub-Saharan Africa remains low compared to the rest of the world – a historical perspective. *International Journal of Water Resources Development*, 36(sup1): S20-S53

- Botero-Valencia, JS., Mejia-Herrera, M. and Pearce, JM. 2022. Low cost climate station for smart agriculture applications with photovoltaic energy and wireless communication. *HardwareX*, 11: 1-21
- Cambaza, C., Hoogesteger, J. and Veldwisch, GJ. 2020. Irrigation management transfer in sub-Saharan Africa: an analysis of policy implementation across scales. *Water International*, 45(1): 3-19
- Emaziye, PO. 2015. The Influences of Temperature and Rainfall on the Yields of Maize, Yam and Cassava among Rural Households in Delta State, Nigeria. *Journal of Biology, Agriculture and Healthcare* 5(1): 1-8
- Emediegwu, LE., Wossink, A. and Hall, A. 2022. The impacts of climate change on agriculture in sub-Saharan Africa: A spatial panel data approach. *World Development*, 158: 1-15
- Ewemoje, TA. and Ewemoje, O. 2011. Best distribution and plotting positions of daily maximum flood estimation at Ona River in Ogun-Oshun river basin, Nigeria. *Agricultural Engineering International: CIGR Journal*, 13(3): 1-13
- FAO. 2023. *Africa – Regional Overview of Food Security and Nutrition 2023: Statistics and trends*. FAO. 89 pp.
- Gaviglio, A., Filippini, R., Madau, FA., Marescotti, ME. and Demartini, E. 2021. Technical efficiency and productivity of farms: a periurban case study analysis. *Agricultural and Food Economics*, 9(1): 1-11
- Giller, KE. 2020. The Food Security Conundrum of sub-Saharan Africa. *Global Food Security*, 26
- Guebsi, R., Mami, S. and Chokmani, K. 2024. Drones in Precision Agriculture: A Comprehensive Review of Applications, Technologies, and Challenges. *Drones*, 8(11): 1-30
- Hanjra, MA. and Williams, TO. 2020. Global Change and Investments in Smallholder Irrigation for Food and Nutrition Security in Sub-Saharan Africa. In S. Gomez y Paloma, L. Riesgo, & K. Louhichi (Eds.), *The Role of Smallholder Farms in Food and Nutrition Security* (pp. 99-131). Springer International Publishing. https://doi.org/10.1007/978-3-030-42148-9_6
- Hellegers, P. and van Halsema, G. 2021. SDG indicator 6.4.1 “change in water use efficiency over time”: Methodological flaws and suggestions for improvement. *Science of The Total Environment*, 801: 1-10
- Ikuemonisan, ES. 2024. Challenges and strategies in Nigerian agribusiness entrepreneurship for sustainable development. *CABI Agriculture and Bioscience*, 5(1): 1-15
- Kamgnia, BD. and N’Dri, KD. 2025. Hunger and Malnutrition in a COVID-19 Environment: What Are the Effects Amidst Rising Food Prices in Sub-Saharan Africa? *Economies*, 13(6): 1-26
- Kumar, RS., Kundu, S., Kundu, B., Binu, NK. and Shaji, M. (2021). Emerging typology and framing of climate-resilient agriculture in South Asia☆. In T. M. Letcher (Ed.), *The Impacts of Climate Change* (pp. 255-287). Elsevier. <https://doi.org/https://doi.org/10.1016/B978-0-12-822373-4.00021-5>
- Li, T., Zhang, X-p., Liu, Q., Liu, J., Chen, Y-q. and Sui, P. 2022. Yield penalty of maize (*Zea mays* L.) under heat stress in different growth stages: A review. *Journal of Integrative Agriculture*, 21(9): 2465-2476
- Majeed, Y., Khan, MU., Waseem, M., Zahid, U., Mahmood, F., Majeed, F., Sultan, M. and Raza, A. 2023. Renewable energy as an alternative source for energy management in agriculture. *Energy Reports*, 10: 344-359
- Miladinov, G. 2023. Impacts of population growth and economic development on food security in low-income and middle-income countries. *Frontiers in Human Dynamics*, 5: 1-17
- Minoli, S., Jägermeyr, J., Asseng, S., Urfels, A. and Müller, C. 2022. Global crop yields can be lifted by timely adaptation of growing periods to climate change. *Nature Communications*, 13(1): 1-10

- Mupaso, N., Makombe, G. and Mugandani, R. 2023. Smallholder irrigation and poverty reduction in developing countries: a review. *Heliyon*, 9(2): 1-15
- Mwamakamba, SN., Sibanda, LM., Pittock, J., Stirzaker, R., Bjornlund, H., van Rooyen, A., Munguambe, P., Mdemu, MV. and Kashaigili, JJ. 2017. Irrigating Africa: policy barriers and opportunities for enhanced productivity of smallholder farmers. *International Journal of Water Resources Development*, 33(5): 824-838
- Obaideen, K., Yousef, BAA., AIMallahi, MN., Tan, YC., Mahmoud, M., Jaber, H. and Ramadan, M. 2022. An overview of smart irrigation systems using IoT. *Energy Nexus*, 7: 1-16
- Odufa, MK., Saudu, TC. and Oladimeji, TE. 2019. Development of a Small Hydropower Plant: Case of Ikere Gorge Dam, Oyo State, Nigeria. *Journal of Power and Energy Engineering*, 7: 31-45
- OECD. 2020. *OECD/FAO (2020), OECD-FAO Agricultural Outlook 2020-2029*, OECD Publishing, Paris/FAO, Rome, .
- OECD/FAO. 2016. *OECD-FAO Agricultural Outlook 2016-2025* OECD Publishing, Paris. http://dx.doi.org/10.1787/agr_outlook-2016-en. 137 pp.
- OECD/FAO. 2024. *OECD/FAO (2024), OECD-FAO Agricultural Outlook 2024-2033*, OECD Publishing, Paris/FAO, Rome, <https://doi.org/10.1787/4c5d2cfb-en>.
- Ojekunle, ZO., Ojo, KO., Idowu, OA., Martins, O., Oluwasanya, GO, and Ojekunle, VO. (2011). Evaluation of Sustainable Water Demand in a Coastal Environment using WEAP Model. *Proceedings of the Environmental Management Conference* 539-552,
- Olayide, OE., Tetteh, IK. and Popoola, L. 2016. Differential impacts of rainfall and irrigation on agricultural production in Nigeria: Any lessons for climate-smart agriculture? *Agricultural Water Management*, 178: 30-36
- Ongoma, V., Brouziyne, Y., Bouras, EH. and Chehbouni, A. 2025. Closing yield gap for sustainable food security in sub-Saharan Africa – progress, challenges, and opportunities. *Frontiers in Agronomy*, 7: 1-8
- Osuji, EE., Olaolu, MO. and Tim-Ashama, AC. 2023. Impacts of Climate Change on Sustainable Crop Production in Nigeria. In JC. Egbueri, JO. Ighalo and CB. Pande (Eds.), *Climate Change Impacts on Nigeria: Environment and Sustainable Development* (pp. 39-56). Springer International Publishing. https://doi.org/10.1007/978-3-031-21007-5_3
- Rai, RK., Singh, VP. and Upadhyay, A. 2017. Chapter 20 - Financial Appraisal of Irrigation Projects. In R. K. Rai, V. P. Singh, & A. Upadhyay (Eds.), *Planning and Evaluation of Irrigation Projects* (pp. 569-603). Academic Press. <https://doi.org/https://doi.org/10.1016/B978-0-12-811748-4.00020-0>
- Rajak, P, Ganguly, A, Adhikary, S and Bhattacharya, S. 2023. Internet of Things and smart sensors in agriculture: Scopes and challenges. *Journal of Agriculture and Food Research*, 14: 1-13
- Rufai, AM., Ogunniyi, AI., Salman, KK. Salawu, MB. and Omotayo, AO. 2021. Rural Transformation and Labor Market Outcomes among Rural Youths in Nigeria. *Sustainability*, 13(24): 1-18
- Soussi, A, Zero, E, Sacile, R, Trincherro, D. and Fossa, M. 2024. Smart Sensors and Smart Data for Precision Agriculture: A Review. *Sensors*, 24(8): 26-47
- Suraj, MM., Martey, E, Kuwornu, JKM., Apiors, EK., Kemeze, FH. and Etwire, PM. 2025. Membership of water user association and implications for food security. *Journal of Agriculture and Food Research*, 20: 1-10
- Tadele, Z. (2017). Raising Crop Productivity in Africa through Intensification. *Agronomy*, 7(1), 1-30.
- Tajudeen, TT., Omotayo, A., Ogundele, FO. and Rathbun, LC. 2022. The Effect of Climate Change on Food Crop Production in Lagos State. *Foods*, 11(24): 1-15

- Takeshima, H. and Adesugba, MA. 2014. Irrigation potential in Nigeria: Some perspectives based on factor endowments, tropical nature, and patterns in favorable areas. . In. Washington, D.C.: International Food Policy Research Institute
- UN. 2023. The United Nations on Global Food Security. *Population And Development Review*, 49(4): 981-984
- Villacis, AH., Mayorga, J. and Mishra, AK. 2022. Experience-based food insecurity and agricultural productivity in Nigeria. *Food Policy*, 113: 1-17
- Xie, H., You, L. and Takeshima, H. 2017. Invest in small-scale irrigated agriculture: A national assessment on potential to expand small-scale irrigation in Nigeria. *Agricultural Water Management*, 193: 251-264
- Yadav, M., Vashisht, BB., Jalota, SK., Jyolsna, T., Singh, SP., Kumar, A., Kumar, A. and Singh, G. 2024. Improving Water Efficiencies in Rural Agriculture for Sustainability of Water Resources: A Review. *Water Resources Management*, 38(10): 3505-3526
- Yaqoob, AM., Omonona, BT. and Salau, MA. 2021. Analysis of Technical Efficiency and its Determinants among Irrigated Watermelon Farmers belonging to Ogun-Osun River Basin Development Authority in Oyo State. *Journal of Research in Agriculture and Animal Science*, 8(11): 1-8